

8. Pinniped research at Cape Shirreff, Livingston Island, Antarctica, 1999/2000; submitted by Michael E. Goebel, Matthew Rutishauser, Brian Parker, Alison Banks, Daniel P. Costa, Nick Gales, and Rennie S. Holt.

8.1 Objectives: Pinniped research was conducted by the U.S. AMLR Program at Cape Shirreff, Livingston Island, Antarctica (62°28'S, 60°46'W) during the 1999/2000 season. Studies on the foraging ecology and energetics of adult female fur seals were conducted by the University of California-Santa Cruz in collaboration with the US-AMLR Program. A four-person field team arrived at Cape Shirreff via the R/V *Lawrence M. Gould* on 31 October 1999. Research activities were initiated soon after and continued until closure of the camp on 9 March 2000. Our research objectives for the 1999/2000 field season were to:

- A. Monitor Antarctic fur seal female attendance behavior (time at sea foraging and time ashore attending a pup);
- B. Assist Chilean researchers in collecting length, girth, and mass for fur seal pups every two weeks throughout the season;
- C. Document fur seal pup production at designated rookeries on Cape Shirreff and assist Chilean colleagues in censuses of fur seal pups for the entire Cape and the San Telmo Islands;
- D. Collect fur seal scats weekly for diet studies;
- E. Collect a milk sample at each adult female fur seal capture for fatty acid signature analysis and diet studies;
- F. Deploy time-depth recorders on adult female fur seals for diving studies;
- G. Record at-sea foraging locations for adult female fur seals using ARGOS satellite-linked transmitters;
- H. Measure at-sea metabolic rates and foraging energetics of lactating female fur seals using doubly-labeled water (deployments to coincide with the US-AMLR Oceanographic Survey cruises);
- I. Tag fur seal pups for future demographic studies;
- J. Extract a lower post-canine tooth from adult female fur seals for aging studies;
- K. Measure metabolic rates (O₂ consumption) and thermo-neutral zones of pups and juvenile (yearling) Antarctic fur seals using a metabolic chamber; and
- L. Deploy a weather station for continuous recording of wind speed, wind direction, ambient temperature, humidity and barometric pressure during the study period;

8.2 Accomplishments:

A. Female Fur Seal Attendance Behavior: Sometime after parturition, Otariid females begin a cyclical series of trips to sea and visits to shore to suckle their offspring. These cycles are called attendance behavior. Measuring changes in attendance patterns (especially the duration of trips to sea) of lactating Otariids is one of the standard indicators of a change in the foraging environment. We instrumented 24 lactating females from 5-11 December 1999. The study was conducted according to CCAMLR protocol (CCAMLR Standard Method C1.2 Procedure A) using VHF radio transmitters (Advanced Telemetry Systems, Inc., Model 7PN with a pulse rate of 40ppm). Presence or absence on shore was monitored for each female every 30 minutes for 30 seconds. All females were instrumented 1-2 days post-partum (determined by the presence of a newborn or a pup with an umbilicus) and were left undisturbed for at least their first six trips to sea. Pups were captured at the same time as their mothers, and weighed, measured, and marked with an identifying bleach mark. The health and condition of the pups were monitored throughout the study by making daily visual observations. One of the 24 females lost her pup during her perinatal period and we report results for the remaining 23. Our record of presence and absence was nearly continuous throughout the season (5 December-9 March) except for two breaks. The first break began midnight 31 December (a Y2K software problem); the break was corrected by 11a.m. 1 January. The second break was longer. It began at midnight 31 January on both recording systems (the main recorder located on the ridge above Maderas beach and the backup recorder located on El Condor). The problem was not discovered until 6 February at 10:51 and was corrected then.

The first female in our study of attendance patterns to begin her foraging cycles did so on 10 December 1999. The last female to complete six trips to sea did so on 26 January 2000. The mean trip duration for the combined first six trips to sea this year was less than the previous two seasons (Table 8.1; Figure 8.1; ANOVA, $df_{2,501}$, $p < 0.005$). Visit durations were also longer in 1999/00 than in 1997/98 and 1998/99 (Table 8.1; Figure 8.1; ANOVA, $df_{2,501}$, $p < 0.005$). In two out of the three years (1998/99 and 1999/00), the distribution of trip durations was skewed to longer trips (Table 8.1; Figure 8.2). Visit durations for all three years were likewise skewed (Table 8.1). There was also less variance in the duration of trips to sea in 1999/2000 than in the previous two seasons (Figure 8.1).

There was no difference in the postpartum mass of our attendance females for 1998/99 and 1999/2000. Females in 1998/99 and 1999/2000 were, however, larger than females in 1997/98 (Figure 8.3a; ANOVA, $df_{2,83}$, $p < 0.0001$; **97/98:** Mean=39.2kg \pm 5.76, N=31; **98/99:** Mean=45.6kg \pm 6.67, N=32; **99/00:** Mean=46.5kg \pm 5.90, N=23). This is because females in that year were sampled later (21-31 December) and late arriving females tend to be younger and smaller. The mass-to-length ratio for all three years was not different (Figure 8.3b; ANOVA, $df_{2,83}$, $p < 0.58$; **97/98:** Mean=0.338 \pm 0.033, N=31; **98/99:** Mean=0.347 \pm 0.041, N=32; **99/00:** Mean=0.346 \pm 0.034, N=23).

B. Fur Seal Pup Growth: Measures of fur seal pup growth was a collaborative effort between the US research team and Chilean researchers. Data on pup weights and measures were collected every two weeks beginning on 16 December and ending 1 March (six bi-weekly samples). Data

were collected as directed in CCAMLR Standard Method C2.2 Procedure B. Growth rates for male pups were higher this year than last (Torres, unpublished data); results will be submitted to CCAMLR by Chilean colleagues.

C. Fur Seal Pup Production: Fur seal pups (live and dead) and females were counted by US researchers at four main breeding beaches (Copihue, Maderas, Cachorros, and Chungungo) on the east side of the Cape. Censuses were conducted every other day from 2 November 1999 through 9 January 2000. The maximum number counted at the combined four beaches in 1999/2000 was 2,104 on 3 January 2000 (Figure 8.4), a 5.8% increase over the maximum count for the same sites in 1998/99 (1,983 on 27 December 1998). The median date of pup births was 8 December, two days earlier than in the previous two seasons.

With increasing numbers of pups at Cape Shirreff, there is some concern that a mark-recapture study should be initiated to get a more accurate estimate of the total number of pups born. Such a study is particularly important at sites where there is tussock grass or terrain that obscures animals from being seen. Cape Shirreff (and the San Telmo Islands) and its beaches, however, are all very open with very few areas, such as boulders or caves, which could obscure pups. Nonetheless, we conducted a study to test the accuracy of our counts. We used the four study beaches that we count every other day. We selected a day (9 January) soon after the last pups were born (estimated from previous years' counts) and before pups begin to disperse from breeding beaches. Three observers counted all pups on the four beaches independently from 16:20-19:00. Each observer counted three times by walking from one end of the study area to the other each time. Weather conditions were dry, partly sunny, 3.9°C, with moderate west wind (15 knots). Results are presented below (Table 8.2).

The overall mean of the nine counts was 1,871 pups (s.e.=44.29). All counts were within 6.6% of the overall mean and the maximum within observer percent difference was only 2.9%. We conclude that even though pup numbers have increased substantially over the last decade at Cape Shirreff, an accurate estimate of the total pup production can still be obtained from simple counts. This is primarily because of the open terrain, low density of animals and the lack of obscuring features.

D. Diet Studies: Information on fur seal diet was collected using three different sampling methods: collection of scats, enemas, and fatty acid signature analysis of milk. In addition to scats and enemas, an occasional regurgitation is found in female suckling areas. Regurgitations often provide whole prey that is only minimally digested. Scats are collected from around suckling sites of females or from captured animals that defecate while captive. Enemas are given to all females that are captured to remove a time-depth recorder or satellite-linked transmitter (PTT). Ten scats were collected every week beginning 29 December. In total, we collected and processed 84 scats, 27 enemas, and 3 regurgitations from 29 December 1999-5 March 2000. Diet samples that were not processed within 24 hours of collection were frozen. All samples were processed by 12 March. Up to 30 krill carapaces were measured from each sample that

contained krill. Otoliths were sorted, dried, identified to species and measured for length and width. The number of squid beaks were counted and preserved in 70% alcohol for later identification. Results indicated an increasing proportion of fish and squid in the diet from December through February and a reduction in the percent of krill from December to January (Figure 8.5). The percentage of krill in the diet remained the same from January through February. Compared to our results from last year, there was more fish and less krill in the diet this year (Table 8.3, $X^2=7.00$, d.f.=2, $p=0.03$).

E. Fatty Acid Signature Analysis of Milk: In addition to scats, enemas, and regurgitations, we collected 201 milk samples from 121 female fur seals. Each time a female was captured (either to instrument or to remove instruments) a 30ml (or less) sample of milk was collected by manual expression. Prior to collection of the milk sample, an intra-muscular injection of oxytocin was administered (0.25ml, 10 UI/ml). The milk sample was returned (within several hours) to the lab where two 0.25ml aliquots were collected and each stored in a solvent-rinsed glass tube with 2ml of Chloroform with 0.01% butylated hydroxytoluene (BHT, an antioxidant). Samples were flushed with nitrogen, sealed, and stored frozen until later extraction of lipid and trans-esterification of fatty acids. Of the 201 samples, 37 were collected from perinatal females and 46 were collected from 34 females that had dive data for the foraging trip prior to milk collection.

F. Diving Studies: Six of our 23 females which were fitted with transmitters for attendance studies, also received a time-depth recorder (TDR, Wildlife Computers Inc., Mark 7, 8.6 x 1.9 x 1.1cm, 27g) on their first visit to shore. All females carried their TDR for at least the first six trips to sea. In addition, all other females captured for studies of foraging locations and energetics also received a TDR. The total number of females with diving data for 1999/2000 was 37. The total number of trips recorded on TDRs from 10 December 1999- 5 March 2000 was 109.

G. Adult Female Foraging Locations and Energetics: We instrumented 34 females with satellite-linked transmitters (ARGOS-linked PTT's) from 29 December- 5 March. Twenty-one carried a PTT for a single trip to sea, five others for two trips to sea and eight females carried their PTT for three trips to sea. Results of fur seal foraging location data analysis and comparisons to the two previous seasons are pending.

H. Foraging Energetics: Twenty (10 in January, 10 in February) of the 34 females we instrumented with PTT's also received an intra-peritoneal (IP) injection of doubly-labeled water (DLW). Each female was captured on her second day on shore, administered DLW, and recaptured as soon as possible on the next visit to shore. The resulting measures of water flux and at-sea metabolic rate are pending and will be presented elsewhere.

I. Demography and Tagging: Together Chilean and US researchers tagged 500 fur seal pups from 20 January- 8 March 2000. All tags placed at Cape Shirreff were Dalton Jumbo Roto tags with white tops and orange bottoms. Each pup was tagged on both fore-flippers with identical numbers (1500-1999). Most pups were tagged on the east side of the Cape from Playa Daniel to Chungungo beach on 31 January and 14 February. Thirty-four tags (1566-1599) were placed on pups at Loberia Beach on the northwest side of the Cape.

In addition to the 500 pups tagged, we also tagged 100 adult lactating females (088-187). All but three tags were placed on females with parturition sites on Copihue, Maderas, Cachorros, and Chungungo beaches. The three remaining tags were placed on females at Loberia.

Last year we added 52 adult females to our tagged population at Cape Shirreff bringing the total tagged population present in 1998/99 to 83 females (Table 8.4). Of these, 78 (94.0%) returned in 1999/2000 to Cape Shirreff and (72) 92.3% returned pregnant. Both return rate and natality were higher in 1999/2000 than in the previous year (Figure 8.7).

Our tagged population of females returned (on average) two days earlier than last year. In 1998/99, the mean date of pupping for tagged females (which had a pup in both years) was 11 December (± 8.0 , $N=67$) and in 1999/2000, for the same females, it was 9 December (± 6.6 , $N=67$). This result agrees with our estimates of the median date of pupping based upon pup counts for the season.

We also observed six yearlings (one female, five males tagged as pups in 1998/99) and 37 2-year-olds (21 females, 14 males, 2 unknowns) that returned to Cape Shirreff in 1999/2000. The first observation of a tagged yearling in 1998/99 was 8 December. This year the first yearling was not observed until 25 January. The return rate for the first year for the two cohorts (97/98 and 98/99) was substantially different (Table 8.5); most of the difference was in the return of females.

The number returning at age 1 is not necessarily an adequate estimate of survival. This is borne out by the return of 2-yr-olds. Of the 22 yearlings observed in 1998/99, only five were observed as 2-yr-olds and 86.5% ($n=32$) of all the 2-yr-olds sighted had not been observed as yearlings. Thus the percent survival for year 1 of the 1997/98 cohort reported in Table 8.6 is a **minimum** estimate. Tag returns of the 1997/98 cohort in future years will determine how close this value is to the actual survival.

Tag loss in our study is high. We calculated the probability of losing a tag by dividing the number missing one tag by the total number of tags (with known tag status). By age two the probability of losing both tags was 0.19 and, for the 1998/99 cohort, it was 0.11. Most tag loss was by the tag hole stretching and the tag falling out rather than by tearing. Tag loss (for the 1997/98 cohort) was higher in females than in males (Table 8.6).

J. Tooth Extraction and Age Determination: We began an effort of tooth extraction from adult female fur seals for age determination in 1999/2000. Tooth extraction was a 3-day effort that began on 21 February. The procedures for extraction of the post-canine were as follows:

- Female fur seals were captured using a hand net containing a strengthened opening in the cod end through which the seal's muzzle fit snugly.
- The seal, restrained by the net, was carried to the anesthesia machine or the machine was brought to the seal, depending on which was more convenient.
- O₂ flow was set at 10 L/min and the vaporizer (containing isoflurane) was set to the maximum of 5%. Before the gas mask (a standard veterinarian mask for a large dog) was placed over the muzzle of the restrained seal, the breathing circuit's exhaust port was closed and the gas mask was blocked with the palm of a hand until the gasbag partially inflated.
- The seal was manually restrained in the net as the gas mask was placed over the protruding muzzle. The exhaust port was then opened about 80%. Once the seal was breathing calmly, the O₂ flow was reduced to 4-5 L/min.
- The anesthetist then monitored the seal's breathing rate and level of consciousness. At all times, the anesthetist kept one hand on the seal's head so as to provide limited control of her head should she arouse. Best results were obtained by keeping the seal on the full 5% isoflurane and 4-5 L/min O₂ until the tooth extraction was completed.
- During the initial placing of the seal on the oral anesthetic, the seal also received an intravenous injection of 1cc of midazolam hydrochloride to further anaesthetize her.
- After the intravenous injection, when the anesthetist deemed the seal sufficiently anaesthetized, the net was removed from the seal and measurements (mass, length, & girth), milking, tagging (if untagged), and finally tooth extraction were conducted. The anesthetist continuously monitored the seal's breathing rate and level of consciousness and suspended tooth extraction operations whenever a seal began to show signs of arousal. (The gas mask must be removed for tooth extraction and the seal usually became aroused within 45 seconds). Tooth extraction rarely took more than 60 seconds.
- Tooth extraction was conducted using a dental elevator to sever the anterior and posterior ligaments of the tooth. Once the tooth ligaments were cut dental extractor pliers were used to pull the tooth using a slight twisting motion.

- After tooth extraction, if release time was going to be a matter of some minutes, the seal was placed on a mixture of 2.5%-3.5% isoflurane & 4 L/min O₂. If release time was expected to occur within 1 minute (for example only weighing of the seal remained), she was placed on the full mixture of 5% isoflurane & 4 L/min O₂. Before final removal of the gas mask, the level of consciousness of the seal was noted and the seal was carried in a weighing stretcher to a distance away (approximately the location of capture). The seal was lifted off the stretcher and placed with the head up-hill and fore-flippers outstretched. Researchers then retreated from the area to allow the seal to arouse slowly without being startled by the presence of the researchers. Released seals were monitored throughout recovery from anesthesia; in all cases, recovery took only several minutes.

The post-canine was successfully extracted from 80 fur seals (41 tagged females, 38 untagged females, one sub-adult tagged male). All females were either tagged and known to have a pup, or untagged and suckling a pup. Females ranged in size from a mass of 31.0-58.2kg and length of 114-144cm. The mean total time captive was 12.6 minutes (± 3.9) and the mean total time under anesthesia was 9.6 minutes (± 2.7 , n=80).

Five females in our sample carried VHF radio transmitters (for the attendance behavior study) before and after tooth extraction. Table 8.7 summarizes data on trip and visit durations for these females. There was no difference in visit durations when comparing the visits preceding tooth extraction, the visit of tooth extraction, and the following visits (ANOVA, $p=0.39$). Similarly, trip durations before and after tooth extraction were not different (paired Student's t-test, $p=0.31$).

The entire sampling for teeth went remarkably well and no adverse post-extraction effects were noted for any individuals. Many of the females were sited suckling their pups on subsequent visits. A subjective assessment of wariness of females on subsequent visits indicated that females that had been captured multiple times for foraging location and energetics studies appeared to be more wary than females that had been captured for tooth extraction. This may be because midazolam, at least in humans, causes temporary amnesia whereas Diazepam (the drug used in routine captures for foraging location and diving studies) does not. Thus females administered Diazepam may have better recollection of capture experiences than those administered Midazolam.

Age determination of extracted teeth is currently underway.

K. Metabolic Rates of Pups and Juveniles: Survival in the first year of life is a critical part of the life history in long-lived vertebrates. In most Otariid species, it is difficult or impossible to study age one animals because they do not return to the natal rookery and are often not seen again until they are several years old. This makes it difficult to assess the important factors that allow survival through their first year of life. In contrast to many Otariid species, yearlings of Antarctic fur seals have a relatively high rate of return to their natal rookery, making them ideal candidates to examine two important factors of their life history: energy stores and thermal homeostasis. Soon after weaning, fur seal pups must learn to find adequate food and maintain their body

temperature in water close to freezing. Because blubber is both an energy store and an insulator, body composition is likely to play an important role in survivorship to age one.

We used a metabolic chamber to measure metabolic rates and thermo-neutral zones, and tritiated water to measure body composition for six yearlings and five molted pups. The energetic data collected with these measures also provides the means to produce a simple model to examine how long a weaned animal can survive before it must forage successfully.

L. Weather at Cape Shirreff: A weather data recorder (Davis Weather Monitor II) was set up at Cape Shirreff from 16 November 1999 to 6 March 2000. The data logger was set up at the US-AMLR field camp. The recorder archived wind speed and direction, barometric pressure, temperature, humidity, and rainfall at 15-minute intervals. The sampling rate for wind speed, temperature, and humidity was every eight seconds; the averaged value for each 15-minute interval was stored in memory. Barometric pressure was measured once at each 15-minute interval and stored. When wind speed was greater than 0, the wind direction for each 8-second interval was stored in one of 16 bins corresponding to the 16 compass points. At the end of the 15-minute archive interval, the most frequent wind direction was stored in memory.

Mean daily temperature at Cape Shirreff was (on average) warmer this year than in 1998/99 for the time period 4 December-24 February ($t_{0.05(2), 82} = -1.98$, $p=0.05$, **1998/99:** 2.23 °C, s.e.=0.11, **1999/00:** 2.51 °C, s.e.=0.11). There was also slightly less precipitation and fewer days of measurable precipitation for the time period 21 December-24 February (**1998/99:** 59.6mm for 43 days, **1999/00:** 57.1mm for 35 days). Cape Shirreff had less over-winter snow cover at the start of this season, although we do not have a precise measure of this. By the time fur seal pupping began in late November, most snow had melted from the breeding areas. The lighter snow cover and decreased precipitation resulted in a relatively dry season for the Cape. Warmer, dryer conditions at the Cape may (in part) explain improved growth rates of pups. When weather conditions are favorable, pups may put more into energetic reserves and growth, and less into thermoregulation.

8.3 Preliminary Conclusions: Fur seal pup production at US-AMLR study beaches on Cape Shirreff increased by 5.8% in 1999/2000 over last year. The median date of pupping based on pup counts was two days earlier. The mean arrival and parturition dates for our tagged female population was also two days earlier. Indicating that females did indeed arrive earlier and not simply that there were fewer late-arriving females. Return rates for adult females indicate good over-winter survival and no change in arrival condition compared to last year. Return rate of yearlings, however, was lower this year than last. Adult female trip duration for the first six trips to sea was significantly less than in the last two years indicating improved foraging conditions. Fur seals had slightly more fish in the diet than last year and the trend for an increasing percent occurrence of fish and squid as the season progresses was evident this year as last year. In general, the 1999/2000 season was better for fur seals by several measures than the previous two seasons at Cape Shirreff.

8.4 Acknowledgements: We are most grateful to our Chilean colleagues: Veronica Vallejos, Olivia Blank, Layla Osmund, Jorge Acevedo, and Mario Brione for their assistance in the field, good humor and for sharing their considerable knowledge and experience of Cape Shirreff. We are also grateful to Terrance Carten and Michael Taft for their considerable help with Pinniped studies. We are particularly grateful to the captain and crew of the R/V *Lawrence M. Gould* who provided transport and assistance to the Cape Shirreff opening team. Without their help we would not have been able to start our studies on time. We are, likewise, grateful to the AMLR personnel and the Russian crew of the R/V *Yuzhmorgeologiya* for their invaluable support and assistance to the land-based AMLR personnel. Studies on the foraging ecology and energetics of fur seals and the metabolic rates of juvenile fur seals were supported by National Science Foundation Grant #OPP 9726567.

Year	Mean (days)	St.Dev.	N	Range	Skewness¹	SE	Significance (-/+)	
Trip Durations:								
1997/98	4.19	1.35	180	8.58	0.0835	0.1811	0.46	-
1998/99	4.65	1.82	186	11.11	0.8498	0.1782	4.77	+
1999/00	3.47	1.00	138	7.65	1.2450	0.2063	6.03	+
Visit Durations:								
1997/98	1.35	0.46	180	2.22	0.6093	0.1816	3.36	+
1998/99	1.32	0.54	186	3.28	0.9469	0.1782	5.31	+
1999/00	1.71	0.63	138	4.15	1.0880	0.2063	5.27	+

¹Skewness: A measure of asymmetry of the distribution of the data. A significant positive value indicates a long right tail. Significance is indicated when the absolute value of Skewness/SE is greater than two.

Table 8.1 Summary statistics for the first six trips and visits (non-perinatal) for female Antarctic fur seals rearing pups at Cape Shirreff, Livingston Island, 1997/98-1999/00.

Observer Count Total Observer			Within Observer		% Difference
#	#	Pups	Mean	S.E.	From Overall Mean
					% Difference
1	1	1871			0.4
1	2	1900			1.2
1	3	1863	1878	11.24	0.8
2	1	1889			2.9
2	2	1952			0.4
2	3	1993	1945	30.25	2.5
3	1	1747			2.5
3	2	1787			0.3
3	3	1841	1792	27.24	2.8

Table 8.2 Results of multiple counts of total pup production by three observers on the east-side beaches (Copihue to Chungungo) of Cape Shirreff, Livingston Island. Counts include newly dead pups present on 9 January but not those counted in censuses prior to that date.

1998/99			1999/2000	
Prey	Observed	Expected	Observed	Expected
Krill	84	73.5	94	105.0
Fish	32	42.5	71	60.5
Squid	12	12.0	17	17.0

Table 8.3 Results of a contingency table on the proportions of major prey types (krill, fish, and cephalopods) in Antarctic fur seal scats and enemas collected at Cape Shirreff, Livingston Island in two years, 1998/99 and 1999/2000. Chi-square=7.00, degrees of freedom=2, p=0.03.

Year	Known Tagged Population¹	Returned	Pregnant	% Returned	% Pregnant	Tags Placed
1997/98						37 ²
1998/99	37	31	28	83.8	90.3	52
1999/00	83	78	72	94.0	92.3	100

¹Females tagged and present on Cape Shirreff beaches the previous year.

²Includes one female present prior to the initiation of current tag studies.

Table 8.4 Tag returns and pregnancy rates for adult female fur seal at Cape Shirreff, Livingston Island, 1998/99-1999/00.

Tag Returns in Year 1 (%):	Total	Males	Females
1997/98 Cohort:	22 (4.4)	10 (2.0)	12 (2.4)
1998/99 Cohort:	6 (1.2)	5 (2.0)	1 (0.4)

Table 8.5 A comparison of first year tag returns for two cohorts: 1997/98 and 1998/99. Values in parentheses are percents.

1997/98 Cohort Sightings	Total	Males	Females
Sighted in Year 1:	22	10	12
Additional Tags Sighted in Year 2	32	10	20
Minimum survival in Year 1:	54 ¹	20	32
Tag Loss:			
Unknown tag status:	3	1	2
Both tags present:	29	13	14
Missing 1 tag:	22	6	16
Probability of missing one tag:	0.43	0.32	0.53
Probability of missing both tags ² :	0.19	0.10	0.28
1997/98 Cohort Survival:			
Minimum % Survival 1 st year:	10.8	8.00	12.80
Adjusted % Survival ³ :	12.8	8.80	16.44

¹Includes two sightings of seals of unknown sex.

²Assumes tag loss is independent for right and left tags.

³Adjusted for double tag loss.

Table 8.6 Tag re-sights and minimum percent survival for the 1997/98 cohort.

	Preceding	Tooth Extraction	Next	Preceding	Following
	Visit (d)	Visit (d)	Visit (d)	Trip (d)	Trip (d)
Mean:	1.45	1.83	2.06	2.69	3.12
S.E.:	0.02	0.34	0.39	0.48	0.40
N:	5	5	5	5	5
Max:	1.51	2.87	3.46	3.81	4.69
Min:	1.39	1.21	1.21	1.65	2.55

Table 8.7 Summary of attendance data for 5 females that had a VHF radio transmitter at the time of capture for tooth extraction.

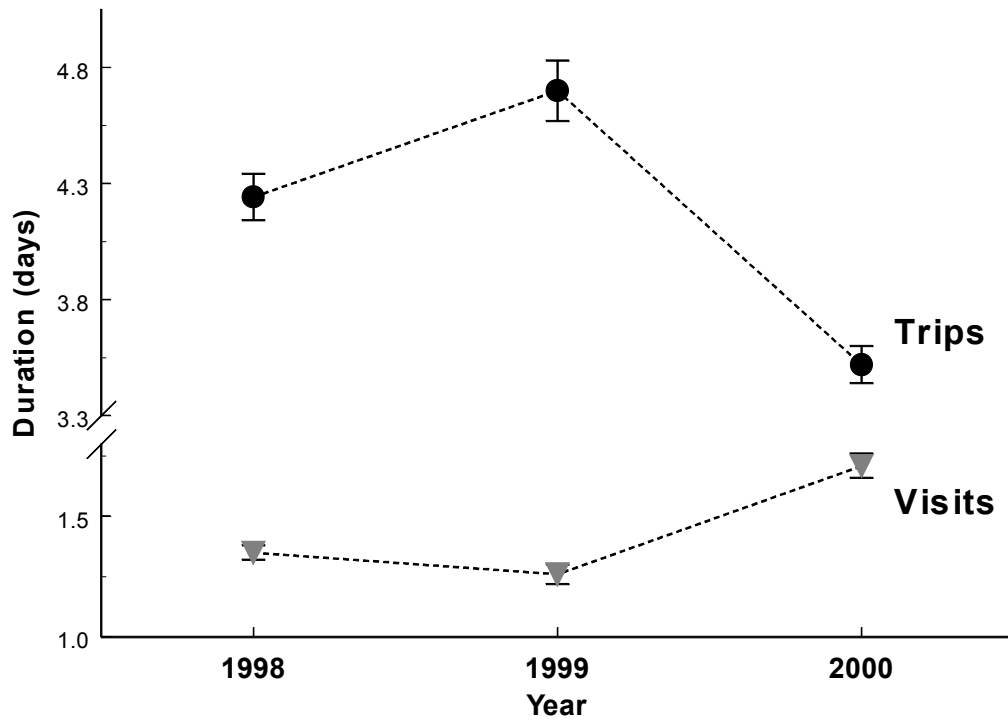


Figure 8.1 Antarctic fur seal trip and visit durations for females rearing pups at Cape Shirreff, Livingston Island. Data plotted are for the first six trips to sea and the first six non-perinatal visits following parturition for the last three years (**1997/98**: $N_{\text{Females}} = 30$, $N_{\text{Trips}} = 180$; **1998/99**: $N_{\text{Females}} = 31$, $N_{\text{Trips}} = 186$; and **1999/2000**: $N_{\text{Females}} = 23$, $N_{\text{Trips}} = 138$). Sample sizes for visits are the same as trips.

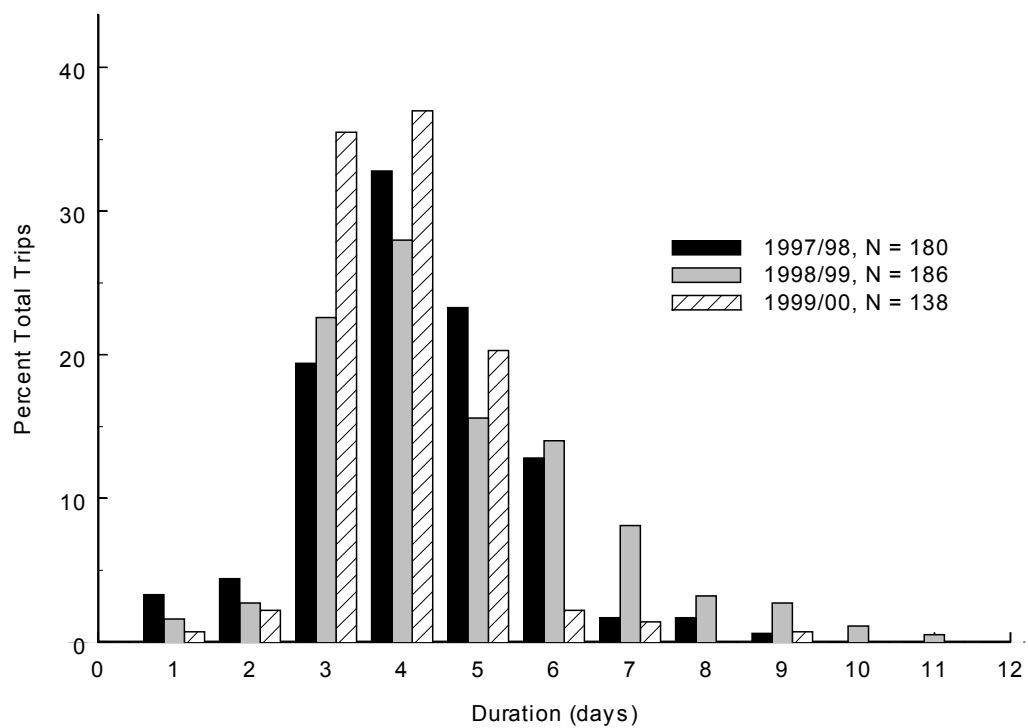


Figure 8.2 Distribution of Antarctic fur seal trip durations for three seasons of study at Cape Shirreff, Livingston Island.

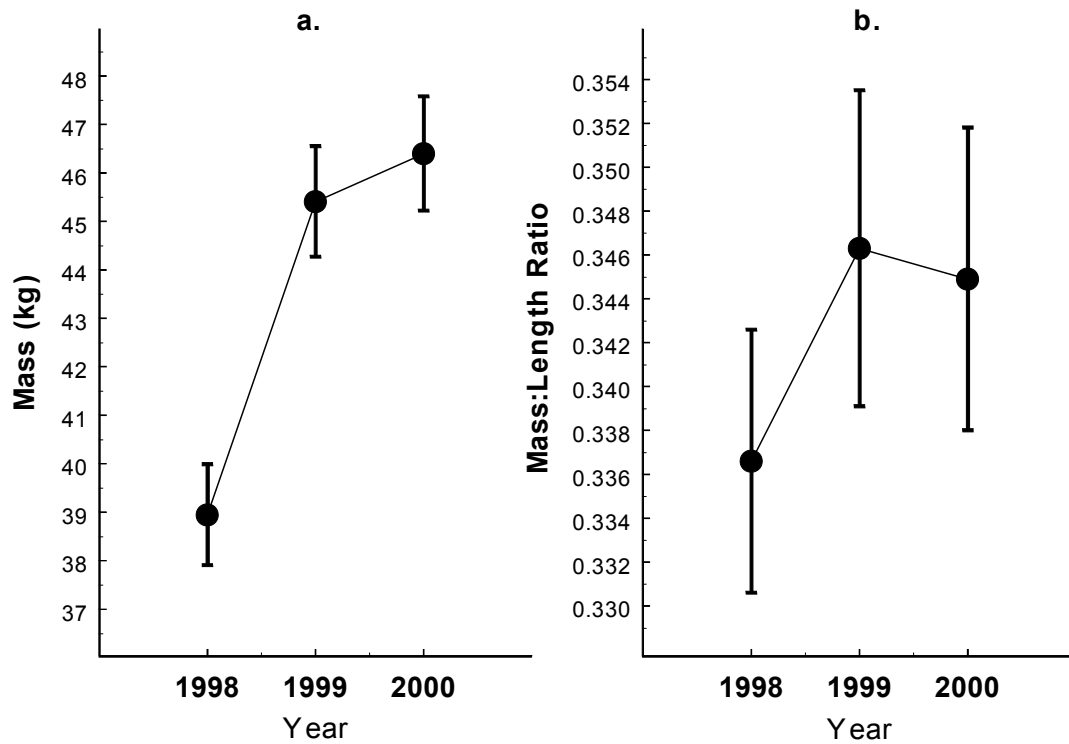


Figure 8.3 a) Mean mass for CCAMLR Attendance Study females for 1997/98-1999/2000 (**1997/98:** N=31, **1998/99:** N=32, **1999/00:** N=23). b) Mean mass to length ratio for CCAMLR Attendance Study females for 1997/98-1999/2000 (**1997/98:** N=31, **1998/99:** N=32, **1999/00:** N=23).

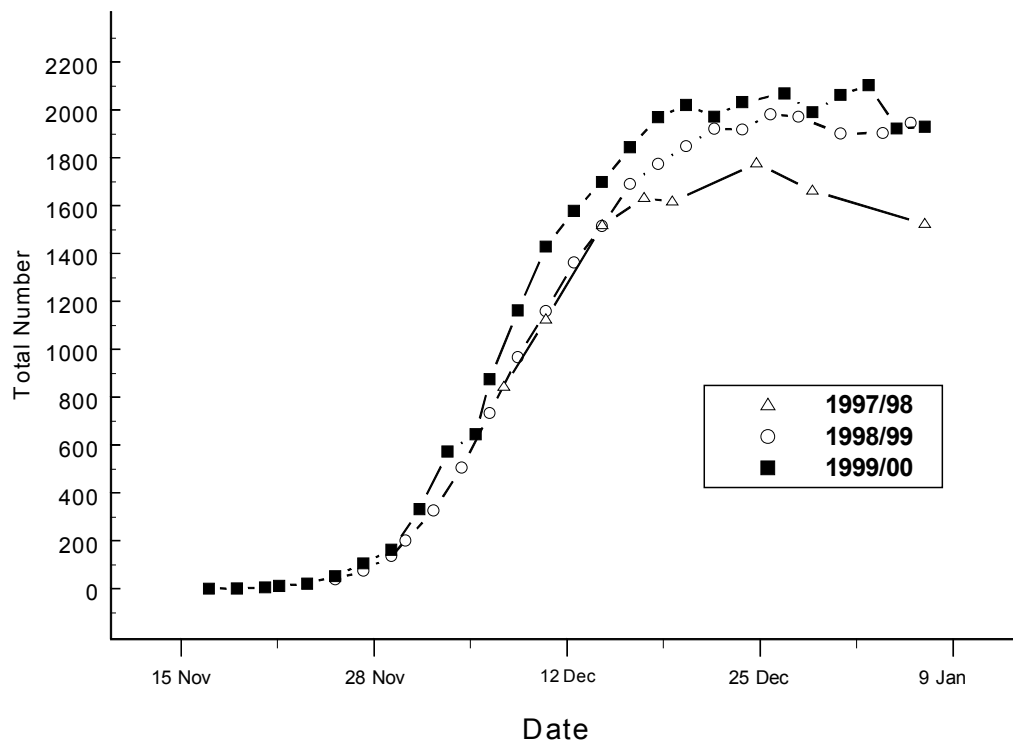


Figure 8.4 Antarctic fur seal pup production at US-AMLR study beaches, Cape Shirreff, Livingston Island, 1997/98-1999/2000.

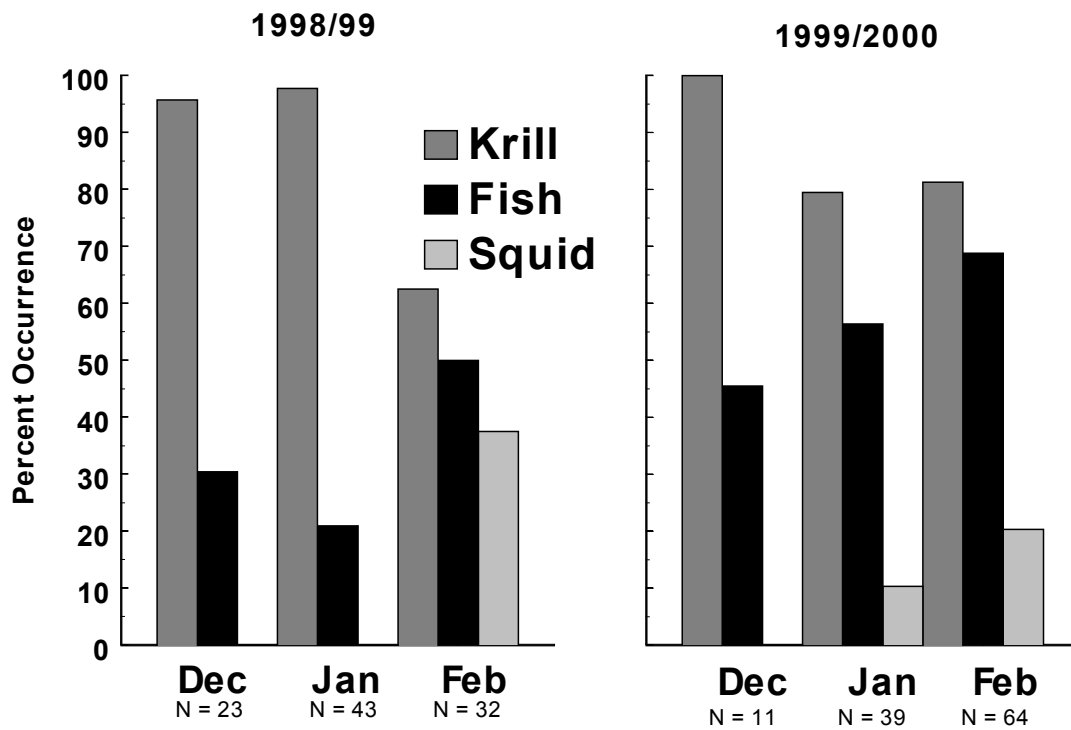


Figure 8.5 Antarctic fur seal diet results from scats, enemas, and regurgitations collected from female suckling areas at Cape Shirreff, Livingston Island for 1998/99 and 1999/00. The percent occurrence of primary prey types (krill, fish, and squid) from December through February are shown.

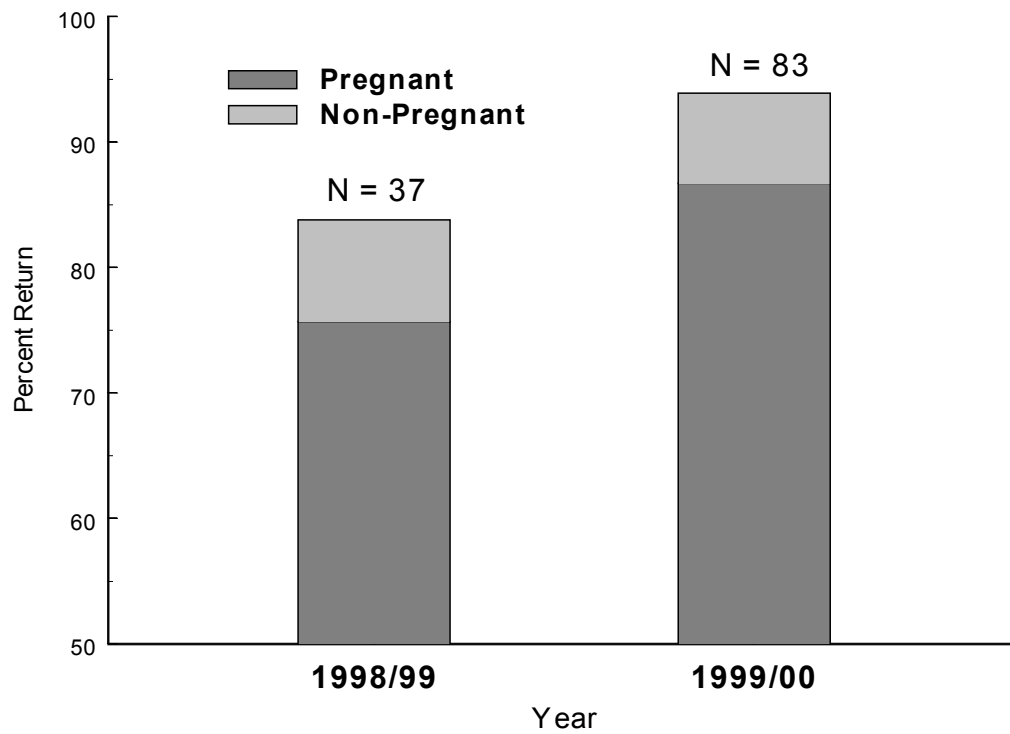


Figure 8.6 Female Antarctic fur seal tag returns for Cape Shirreff, Livingston Island, 1998/99 and 1999/2000.